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ABSTRACT

This study was designed to examine the nature of the interaction among secondary school science teachers, school administrators, and external agents and how these interactions influence the character of the science program. An ethnographic approach was employed in which secondary school science classes from five schools in two districts were observed during an 18 month period. Data were obtained from approximately 675 classroom observations, 200 interviews, and 60 formal interactions at meetings, workshops, and other activities. Findings are classified in four categories relating to: (1) teachers and teaching; (2) interaction among staff and others; (3) factors appearing to underlie observations; and (4) potential for change. Observations are reported in point form for each of these areas. Implications for instruction and researach are also discussed. (ML)

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A Study of Secondary Science Teaching Practices

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Secondary school science teachers serve a key role in communicating the content and nature of science to youth. As the level of technological knowledge required of citizens and workers in our society increases, science teachers are being called upon to provide more science instruction to a wider segment of youth. Societal changes necessitate teaching of high school science to all youth not just those who are college bound. As a result, science teachers must improve their effectiveness in teaching and alter content of instruction so that more youth will be prepared for life and work in a new kind of society.

Data from the post-Sputnik reform movement suggest that secondary science teachers are not prone to modify the content or approach to teaching in response to the availability of new instructional materials or as a consequence of appeals from leading scholars and scientists. Even with strong social pressure of that era, associated substantial involvement of government and universities, and large expenditures for curriculum development, the nature of the implemented curriculum did not change to the degree intended. Often new books were used and more up-to-date content was taught, but the methods of teaching did not change. Moreover, teachers' expectancies of students were typified by strong emphasis on memorization of factual information, with little emphasis on learning skills of inquiry, problem solving, and other components of higher order thought.

Data from research and practical experience imply that while some secondary science teachers provide instruction that nurtures development of inquiry and higher order thinking, the majority focus predominately on lower cognitive skills of recall of factual information and comprehension (Levels 1 and 2 of Bloom's Taxonomy). Data also suggest that some teachers actually devote greatest energy to level 1 objectives.

The seriousness of this situation has been the subject of many reports (Harms and Yager, 1981) and yet little is known about the reasons which underlie it. Contemplation of the situation should prompt questions such as: What conditions prevail in the milieu of secondary schools that permit or prompt the majority of secondary science teachers to teach toward lower order cognitive skills and virtually ignore the higher order ones? Or does the problem eminate from teachers' educational background in universities, from textbooks and other educational resources, from the students, or from the teachers themselves? It is this domain of investigation to which the Institute for Research on Teaching Secondary School Science Project directs itself.

QUESTIONS AND METHODOLOGY

To give a degree of focus to this broad study we chose to raise the general question, "What is the nature of the interactions among secondary school science teachers, school administrators, and external agents and how do these interactions influence the character of the science program? More specific purposes of this study were to:

1. formulate a detailed description of the character and qualities of secondary school science teaching in two school districts.

2. describe the nature of interactions among secondary school science teachers, administrators, and external agents in secondary school in these two districts;

3. attempt to gain insights into the values, attitudes, beliefs, knowledge, and skills that underlie and shape these interactions and the character of the science program;

4. identify sources of new information used by teachers and administrators and describe how this information affects practice;

5. understand the processes by which dialog can be increased among science teachers, secondary school administrators, and external agents in the context of modifying the secondary science program to assist a wider segment of the school population.

These purposes implied the need for descriptions of behavior and investigation of what lies behind that behavior. Due to the nature of the questions asked, the approach used in this study was ethnographic. The principal investigator, six graduate students, and one undergraduate professorial assistant visited five schools in two districts to observe secondary school science classes on a continuing basis over the past 18 months. Informal conversations and meetings, and formal interviews served to provide information about organization and purposes of instruction, content decisions, teaching strategies, and other choices made by teachers, department heads, and administrators. Review of texts, other instructional resources, tests, and policy documents was another important data source as was participant-observation by project staff members who worked with teachers and department heads in classrooms, laboratories, teacher workshops, and planning meetings. During the past year, project staff also has engaged in cooperative activities with school personnel aimed at improvement of science instruction in the schools.

Recently, we have engaged in continuing broad range observations in schools and classrooms to (1) reconfirm and elaborate our earlier findings and (2) determine the values, beliefs, and understandings that underlie the actions we have observed. These continuing broad range activities and our more specific studies, described in the other papers which are part of this symposium, have overlapped in practice. While we were conducting our specific investigations, we also reconfirmed and elaborated more general issues. The total scope of our data acquisition now includes approximately 675 classroom observations, 200 interviews, and 60 other formal interactions at meetings, workshops, and other activities. Data also are supplemented by innumerable informal conversations with faculty and administrators resulting from the close working association that has emerged between them and our staff.

THE SITES

Five schools in two districts have participated in this study. Three schools studied serve students in grades 9 - 12 and two enroll students in grades 6-8. Three of the schools are located in a village community (called Village Schools) and tow are located in a medium-sized city (City Schools).

Most students in the two districts are from middle class families, but some students come from families that are either higher or lower in socio-economic status. Thirty-six teachers teach science in the five schools; thirty-three are now engaged in the study in various ways. In each of the five buildings, the Principal is engaged in the study, albeit rather remotely. In Village Schools, the District Director of Secondary Education is engaged significantly in our work.

FINDINGS

As a way of organizing the volume of data that have been produced from this study, the project staff have formulated assertions based on our findings. Since the project described the real world of teaching practice, each of our assertions was supported by substantial data, but none were supported unequivocally by the data. Exceptions to every assertion were found. Thus, as we assembled our data in support of our assertions, we also compiled data which refuted them, to provide a more complete representation of science teaching in the five schools. It should be noted, however, that even though there were data that refuted each of the assertions, the majority of data were supportive of them.

To assist the readers, assertions have been grouped below in four categories relating to (a) teachers and teaching, (b) interactions among staff and others, (c) factors appearing to underlie observations, and (d) potential for change. These four categories correspond to the research questions listed earlier in this report.

A. Teachers and Teaching

1. Science teaching in the two districts is male dominated; 27 of 36 teachers are males as are the science department heads and the curriculum directors.

2. The secondary science teachers are experienced and, for the most part, are well-qualified in science. Only three who are assigned to teach science full time in the two districts lack a major or minor in the field of assignment. All have taught at least a decade and the average teaching experience approaches 20 years.

3. The rapport between most teachers and the students appears to be friendly and supportive. Observations in classes and outside of them suggest very wholesome adult-youth relationships. In addition, the enthusiasm of the teachers at the beginning of the year was remarkable. Even though enthusiasm flags somewhat through the year, the relationships between students and teachers continues to be strong and supportive.

4. Secondary school science teachers devote little time outside of class to planning and preparation for teaching and in completing the clerical work that is related to grading tests and homework. As a consequence, teachers often are marginally prepared for teaching when they enter the classroom and they use some of the class time for clerical and organizational work related to instruction. During this time, students are assigned seat work, which further adds to the teachers' clerical burden. Films are used frequently by teachers and laboratory activities are only used occasionally; in neither case are they integrated effectively with other instructional components.

5. There is considerable variation among science teachers in the techniques of teaching used in classes but any one teacher uses only a small range of teaching techniques.

6. In spite of variations in techniques among secondary science teachers, science instruction generally focuses on lower order cognitive skills. Applications of scientific knowledge to student's daily life, and higher order thinking skills are not central to instruction for most teachers.

7. Textbooks are given an implied aura of authority and completeness. With the exception of films, few instructional resources are used by teachers to supplement the adopted text in guiding and enriching instruction. Textbooks appear to be the main source of instructional content in secondary science. Supplemental resources are used only occasionally, except for films which tend to be a diversion from, rather that an enrichment for content learning. This connotes that the text contains all essential information, appropriately presented. Students rarely are encouraged to seek another source of content, a different presentation, or another viewpoint.

9. Instruction in elective, high school science courses tends to be reactive, not proactive. Teachers in elective courses tend to give homework without providing students with instruction in the pertinent content. Thus, students must approach the subject matter contained in the homework assignment on their own, with little or no advance help from the teacher, until the next class periods when the teacher will "go over" the homework. At that time, the teacher responds to students' difficulties with the subject matter, in general, and with the homework questions in particular. Moreover, teacher vary in their skill in this reactive approach to teaching. Some teachers simply work the homework problems for the students, while others are more analytical about difficulties students are having with specific elements of the subject matter. Those who try to be analytical about difficulties of students, are required to be perceptive because students who are having difficulties with subject matter frequently are not clear about the nature of their deficiency. In addition, these teachers must also be creative and able to "think on their feet" in order to assist students through examples and analogies formulated often on the spur of the moment. At times, this style of teaching was ineffective because the examples and analogies constructed by the teachers under the pressure of the class were inappropriate. Clearly, reactive teaching, so frequently practiced by teachers of elective courses, is fraught with inherent problems.

10. Teachers interact more frequently, and at higher levels of cognition with more able, highly motivated students than with less able students. Studies by Gallagher and Tobin (1986) and by Cline (1986) as part of this symposium, emphasize the role of "target students" in secondary science instruction.

11. The same teacher may treat different classes differently in both cognitive level and interpersonal quality. A study by Lee (1986) describes this findings as part of this symposium.

B. Interactions among Staff Members

12. Teachers talk with each other about many things -- students, sports, politics, administrators -- but the do not talk about instruction are the curriculum very often.

Moreover, when they do, their talk is neither rich nor elaborated. Instead, it focuses on resolution of specific problems.

13. Teachers and Administrators have relatively little interaction regarding instruction or the curriculum. Both seem to be attending to separate agendas and only work together superficially on matters such as schedules, organization, and student behavior. They rarely discuss what should be taught our how teaching should occur.

14. Teachers tend to be highly autonomous in determining instructional content, methods of teaching, and academic standards. "Boundaries regarding acceptable content, teaching style, and standards are very broad. Each teacher appears to have considerable freedom in determining the content to be taught, the methods of instruction, and standards of expectancy. Thus, teachers have no pressing need to interact about instruction, since each can determine crucial instructional decisions autonomously.

C. Factors Underlying Observations

15. Teachers are overextended. Nearly all teachers teach five periods, five days per week, each with 25 - 30 students, often in three different subject areas. Generally one period is allowed for planning and a lunch break of, perhaps, 20 minutes duration is given. Between classes, there is a five minute break, but teacher are expected to monitor the corridors which are jammed with students, rushing to the next class. Thus, teaching days are full.

In addition, most science teachers are very busy after school with coaching, clubs, civic activities, recreation, planning, grading papers, background reading and enrichment, or learning about new developments in science or new pedagogical approaches. Many activities which teachers perform outside of their teaching duties, bring them closer to youth, help them understand their students better, and make the more interesting and happier people. These activities also tend to leave them both tired and unprepared as the enter their classrooms.

16. Teachers see their role as presenting (covering) information with students. Secondary science teachers' role models are university professors who tend to be presenters of information, and who rarely are concerned with students' learning. Typically, the approach to instruction used by university professors is similar to that used by secondary science teacher in that there is little concern for nurturing students, diagnosing their difficulties with subject matter acquisition, or providing assistance in overcoming these difficulties. Instead, both university professors and secondary science teachers most often adopt the attitude that their role is to present information in a way that will aid in comprehension, give assignments, and then evaluate performance -- good students will learn or lack motivation, it is perceived as the fault of the students and not the fault of the teachers.

Two papers in this symposium will describe investigations about teachers' role perceptions and their findings more fully (Abu-Isneinih, 1986; Lee, 1986).

17. Instruction in science is inappropriately contextualized. Much instruction in secondary school science is decontexualized; few examples are provided for youth that relate "theoretical knowledge" learned in school to the practical realm of their daily experience. On the other hand, we have seen

the converse, as well; that is teachers providing examples of applications without showing their relationship to pertinent theories and principles which the students have studied. This phenomenon may derive from role models addressing basic science with little emphasis on applications. The paper by CONTRERAS (1986) in this symposium describes this research and finding more fully.

18. Many teachers view students as "pre-destined." That is, teachers appear to feel that only a few students have both the natural ability and high motivation to be successful in science and those who lack either or both will be unsuccessful. As a consequence, the pace of instruction is students in classes, who are the best achievers. This is counter to normal intuitions which suggest that the pace of instruction is determined by the average students in the class. Further, while pacing instruction for the most able students has significant benefits for a few, the consequences for the majority of students are harmful in terms of development of understanding of science and personal self-esteem. Cline's study (1986) elaborates these points further.

19. Most teachers perceived that they were effective. Teacher appeared to be satisfied that they had mastered classroom management and the subject matter contained within the text. They also appeared to believe that they could learn little about teaching from one another, from administrators, or from outsiders such as university professors. Knowledge of subject matter content was somewhat different -- teachers sometimes were observed to ask each other (or our staff) about science content, but we were never asked about how to teach it nor did we observe teachers asking each other about teaching strategies.

20. Secondary science teachers acquire new information about science, technology, and teaching at a slow rate and in non-systematic manner. Few secondary science teacher read widely or participate in activities that help them keep pace with new advances in subject matter, its applications in society, or in pedagogy. The chief source of new information about science and technology comes from public TV programs such as NOVA. Since there are no pedagogical counterparts to these programs on science and its applications, teachers acquire very little new information about new developments in their profession.

21. Secondary science teachers have made their job easier than it is. Science teaching is complex and requires thoughtful planning before, intense concentration during, and deep concentration after, the act. Doing it right is very demanding. Perhaps as a "survival mechanism" teachers have "softened their job" through minimizing planning and leaving little time in their lives for reflection. Even the intense concentration while teaching often is reduced by (a) using seat work (b) adhering to a small repertoire of familiar methods, (c) using the same exercises for classes of different ability, (d) using the same text year after year as a single resource for instructional content and (e) not being those teachers newly assigned from another field to teach science felt apprehensive about the difficulty of the task of teaching science. For veteran science teachers, the task was easy and they did it to their satisfaction.

D. Potential for Change

22. Changing the quality, character, or effectiveness of instruction will eminate from a combination of instruction will eminate from combination of

externally changed expectancies and cooperative interaction between teachers, administrators, university staff, and to her external agents of change. This assertion will be elaborated later in Discussion Section of this paper.

These assertions only summarize our data. More detailed reports are in preparation which present both supporting and refuting data. Three Progress Reports are available at this time, from the Institute for Research on Teaching, for those who would like deeper insights into our work. In addition, the reports which comprise the balance of this symposium provided detailed information of specific studies.

DISCUSSION

A question which concerned all members of our staff was the perennial question facing ethnographers-- Are we seeing events as they are or as we want them to be? For us, the question was nearly reversed. We were observing science instruction that did not match our expectations and, as a consequence, we asked if we were missing something because our expectations were not being met. Were there features of science instruction that were eluding us because the model of instruction that we implicitly were using served as a "filter," albeit unknowingly, limiting our ability to see what actually was occurring in the classrooms that we were observing.

To help broaden our vision, project staff members reviewed the literature on models of teaching so that we might be better prepared to detect the subtleties of teachers' actions which may have been evading us. In addition, since we entered schools to determine reasons underlying observed actions and events, our sensitivities to the symposium also served to increase our sensitivities to the matter. For example, probing deeply about teachers' role perceptions should enrich our understandings of the more general observations of teachers' actions. Moreover, if our findings about teachers' role perceptions coincide with their observed classroom behaviors, then we can have greater confidence in the validity of our observations.

Data from our continuing observations appear to strengthen our case. New observations help to enrich our understandings confirm them. Further studies, probing more deeply into the environment of secondary school science teaching, provide us with confidence that our picture of science teaching in the two schools is a valid composite of events. However, it must be remembered that no assertions exist without exceptions and while some teachers' actions and efforts are quite different from the picture portrayed, our overall results represent the realities in these schools.

I hasten to add the following: The teachers in this study should not be viewed as poor teachers who deviate substantially from the norm. They are fine people whom my staff and I have come to know and respect. They hold degrees from excellent universities. Most have a strong background in science, many years of teaching, and a sincere dedication to the students in their classes. Most believe they are doing an effective job, because in their view, their work conforms to that which they have observed in many university courses and they believe that their work conforms to the expectancies of administrators and parents.

Therein lies part of the problem--miscommunication or non-communication of expectancies. Without clear communication of shared goals and purposes of instruction, teachers are adrift without a means of establishing an appropriate direction. The prized concept of local control of education in U.S. schools has turned into individual autonomy--individual teachers each setting their own curriculum including content, method, and standards.

In the school districts studied, there are few incentives for teachers to engage in collective determination of the science curriculum. Some teachers share equipment; a few even share examinations. But beyond these cases, any significant cooperative curricular decision-making is rare. Because of union contracts, meetings to consider the content, standards, and methods of science instruction rarely occur and teachers do not voluntarily engage in such work partly because they appear to lack concepts, skills, and vocabulary for curricular deliberation that could enrich and facilitate this difficult and time consuming activity. Moreover, teachers have little time for such deliberation; they are busy with classes five periods each day and with other activities after school, in the evenings, and on weekends. As a consequence, teachers rely on textbooks for essential curricular decisions.

Unfortunately, few teachers have a clear understanding of the options which textbooks enable. Most high school science textbooks contain more content than can be taught effectively to most students in the time allocated for a typical course; yet most teachers feel a sense of omission, or guilt, if they do not "cover the text." Using a text as a source of elements for a curriculum is not part of most teachers' thinking, nor is adapting the text to meet the needs of specific students or the conditions of a particular environmental setting. This should not be surprising; neither university courses, nor their professors, have provided good models to help with such decisions. Therefore, the whole text becomes the curriculum and teachers "cover it" at a low cognitive level necessitated by a large volume of material and the constraints of time.

How may changes be brought about? Teachers feel that they are doing an effective job (Assertion 19) for several reasons including positive feedback from target students (Assertion 10), consonance of their own actions and role perceptions (Assertion 16), and their belief that many students lack ability or motivation needed to learn science (Assertion 18). Moreover, as a way of coping with the intensity of the secondary school environment and its exuberant youth and their varied needs, interests, and problems, teachers have invented ways to "get by" with minimal stress (Assertion 21) and have filled their lives with other activities to give them added meaning and enrichment (Assertion 15). All of these would appear to add up to a context which would virtually eliminate the potential for change, especially since there is so little substantive dialog between administrators and teachers (Assertion 13) and such a high degree of teacher autonomy about essential instructional decisions (Assertion 14).

A short case study may shed some positive light. During Spring 1985, two graduate assistants and I conducted a series of three workshops for four teachers of sixth grade science who were disenchanted with City Schools' newly adopted science text. Their claim was that it left too much up to the teacher. Their complaints included (a) the text did not contain enough information to allow them to teach science effectively, (b) too many questions were open-ended, calling for diverse responses from students instead of

specific answers, (c) activities were not clearly described, and (d) equipment and materials needed to conduct activities were not available. The department head at City Middle School solicited the assistance of the Principal and resolved point (d) by acquiring needed supplies and organizing storage facilities for them. During three workshops totaling 10 hours in duration, the department head, four teachers, the Principal, two graduate students, and I deliberated on how to resolve the other three points by discussing the goals of the program, clarifying understandings about the desired teaching style, and identifying specific actions for teachers to use when planning lessons based on the book.

The interactions during the meetings were all premised on mutual respect of each person's expertise. This was reinforced through providing teachers with snacks, coffee, and juice at the start of the workshops and a catered dinner near the end of meeting which began about 3:15 p.m. and lasted three and one-half hours. Active engagement in creative problem solving in a cooperative context characterized the three workshops. The volume of content prescribed by the leaders was relatively small. Most ideas were elicited from or volunteered by the teachers. The atmosphere of professional respect was central.

Following the workshops, teachers' level of satisfaction with, and effective use of, the textbook improved markedly. Teachers, department head, and Principal had a better working relationship and shared the program goals more fully than previously. The motive for changing expectations and teaching style was engendered by the text. The workshops provided the social and intellectual environment for cooperative interaction to achieve the changes in teacher behavior that were required to attain the desired outcomes with students. The effort was intense and the numbers reached were small. However, the concept of "cooperative action in response to an external stimulus" appears to be an effective one in bringing about change. Further, other models for implementing the concept, which are less "labor intensive," may be feasible.

SUMMARY

This research enriches our understandings of practices and the environment of secondary school science teaching. Moreover, it provides some understanding of the reasons which underlie observed events and some insights about how changes in practices may be effected through a combination of altered expectancies and cooperative actions by teachers, administrators, university faculty, and other agents of change external to schools. These understandings of the practices and environment of secondary science teaching, and the attitudes and circumstances which underlie them, are important as we look toward needed changes in secondary science teaching in the years ahead. Also this research has significant implications for teacher educators who are concerned with both preservice and inservice education of secondary science teachers.

REFERENCES

Paper delivered at the annual meting of the National Association for Research in Science Teaching, San Franscisco, California, March 28, 1986.